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TITLE: PRODUCTION OF HIGH STRENGTH SEAMLESS STEEL PIPE EXCELLENT IN FRACTURE PROPAGATING RESISTANCE

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ABSTRACT:

PURPOSE: To impart brittle fracture porpagation resistant properties to a steel pipe and to enable its use in the northernmost cold district by subjecting a slab contg. specified amounts of C, Si, Mn, P, S, Al, Ti, Nb, N and Fe to heating treatment and forming under specified conditions.

CONSTITUTION: A slab constituted of, by weight, 0.03 to 0.2%. C, 0.01 to 0.5% Si, 0.15 to 2.5% Mn, ≤0.02% P, 0.005 to 0.1% S, 0.005 to 0.1% Al, 0.005 to 0.1% Ti, 0.005 to 0.1% Nb and ≤0.01% N, and the balance substantially Fe is heated to ≥ 1100°C and is subjected to hot piercing rolling into hollow pipe stock. This pipe stock is cooled to the Ar3 point to 1100°C, is subjected to forming at 20 to 70%. percentage reduction of area in thickness by a skew rolling mill of the preceding stage and is subjected to 20 to 70% forming by a final skew rolling mill. This steel pipe is thereafter subjected to hardening treatment of executing shape straightening continuous rolling by 20 to 70% at the Ar1 point to 900°C and rapidly cooling it from the Ar3 point or above and is thereafter subjected to tempering treatment of heating it to the A1, point or below and executing cooling.

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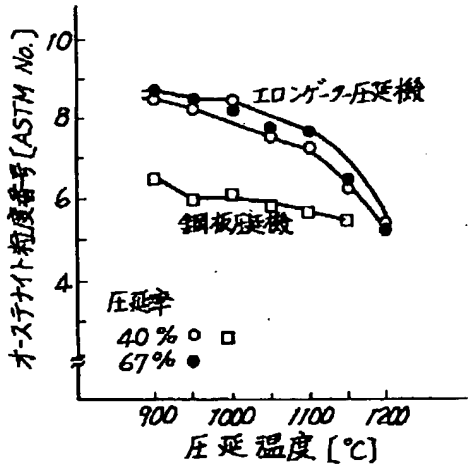
(54)【発明の名称】　破壊伝播特性の優れた高強度シームレス鋼管の製造法

(57)【要約】

【目的】　シームレス圧延ままでオーステナイト（γ）粒度１０番以上を得、その後のＤＱＴ処理により破壊伝播特性の優れたシームレス鋼管を得る。

【構成】　１１００℃以上に加熱された鋼片を穿孔圧延して得られた中空素管を、前段および最終段の傾斜圧延機前にＡｒ３点～１１００℃にして、それぞれの傾斜圧延機で断面減少率にして２０～７０％の加工を施し、更にその後の連続圧延機でＡｒ３点～９００℃間で２０～７０％の加工を施し、ＡＳＴＭ No. １０以上のγ粒を得その後焼入焼戻しを行う。

【効果】　傾斜圧延機は剪断ひずみが大きいため通常の他の圧延機に比べて得られるγ粒度は９番以上で、更に直後の連続圧延で１０番以上の未再結晶の微細γ粒が得られる。未再結晶かつ微細γ粒からの焼入焼戻し処理により破壊伝播特性の優れたシームレス鋼管が得られる。



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【特許請求の範囲】

【請求項1】　重量%として

C　：0．03～0．20%、
Si：0．01～0．5%、
Mn：0．15～2．5%、
P　：0．020%以下、
S　：0．005～0．1%、
Al：0．005～0．1%、
Ti：0．005～0．1%、
Nb：0．005～0．1%、
N　：0．01%以下

を含有して残部が実質的にFeからなる鋼片を1100℃以上に加熱熱間穿孔圧延した中空素管をAr_3点～1100℃まで冷却し、その直後の前段の傾斜圧延機で肉厚断面減少率で20～70%の成形加工を施し、更に前段傾斜圧延による加工発熱でAr_3点～1100℃まで昇温保持された中空粗管をその最終傾斜圧延機で肉厚断面減少率で20～70%の成形加工を施し、その後、形状矯正連続圧延をAr_1点～900℃の温度で20～70%の施した鋼管を、Ar_3点以上の温度から急冷する焼入処理を施した後、続いてAc_1点以下の温度に加熱して冷却する焼戻し処理を行うことを特徴とする破壊伝播特性の優れた高強度シームレス鋼管の製造法。

【請求項2】　重量%として、

C　：0．03～0．20%、
Si：0．01～0．5%、
Mn：0．15～2．5%、
P　：0．020%以下、
S　：0．005～0．1%、
Al：0．005～0．1%、
Ti：0．005～0．1%、
Nb：0．005～0．1%、
N　：0．01%以下

を含有して、更に

Cr：0．1～1．5%、
Mo：0．05～0．5%、
Ni：0．1～2．0%、
V　：0．01～0．1%、
B　：0．0003～0．0033%

の1種又は2種以上を含有して残部が実質的にFeからなる鋼片を1100℃以上に加熱し熱間穿孔圧延した中空素管をAr_3点～1100℃まで冷却し、その直後の前段の傾斜圧延機で肉厚断面減少率で20～70%の成形加工を施し、更に前段傾斜圧延による加工発熱でAr_3点～1100℃まで昇温保持された中空粗管をその最終傾斜圧延機で肉厚断面減少率で20～70%の成形加工を施し、その後、形状矯正連続圧延をAr_1点～900℃の温度で20～70%の施した鋼管を、Ar_3点以上の温度から急冷する焼入処理を施した後、続いてAc_1点以下の温度に加熱して冷却する焼戻し処理を行うことを特徴とする破壊伝播特性の優れた高強度シームレス鋼管の製造法。

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【請求項3】　重量%として、

C　：0．03～0．20%、
Si：0．01～0．5%、
Mn：0．15～2．5%、
P　：0．020%以下、
S　：0．005～0．1%、
Al：0．005～0．1%、
Ti：0．005～0．1%、
Nb：0．005～0．1%、
N　：0．01%以下

を含有して、更に

希土類元素：0．001～0．05%、
Ca：0．001～0．02%、
Co：0．05～0．5%、
Cu：0．1～0．5%

の1種又は2種以上を含有して残部が実質的にFeからなる鋼片を1100℃以上に加熱し熱間穿孔圧延した中空素管をAr_3点～1100℃まで冷却し、その直後の前段の傾斜圧延機で肉厚断面減少率で20～70%の成形加工を施し、更に前段傾斜圧延による加工発熱でAr_3点～1100℃まで昇温保持された中空粗管をその最終傾斜圧延機で肉厚断面減少率で20～70%の成形加工を施し、その後、形状矯正連続圧延をAr_1点～900℃の温度で20～70%の施した鋼管を、Ar_3点以上の温度から急冷する焼入処理を施した後、続いてAc_1点以下の温度に加熱して冷却する焼戻し処理を行うことを特徴とする破壊伝播特性の優れた高強度シームレス鋼管の製造法。

【請求項4】　重量%として、

C　：0．03～0．20%、
Si：0．01～0．5%、
Mn：0．15～2．5%、
P　：0．020%以下、
S　：0．005～0．1%、
Al：0．005～0．1%、
Ti：0．005～0．1%、
Nb：0．005～0．1%、
N　：0．01%以下

を含有して、更に

Cr：0．1～1．5%、
Mo：0．05～0．5%、
Ni：0．1～2．0%、
V　：0．01～0．1%、
B　：0．0003～0．0033%

の1種又は2種以上と

希土類元素：0．001～0．05%、
Ca：0．001～0．02%、
Co：0．05～0．5%、

Cu：0．1～0．5%
の1種又は2種以上を含有して残部が実質的にFeからなる鋼片を1100℃以上に加熱し熱間穿孔圧延した中空素管をAr3 点～1100℃まで冷却し、その直後の前段の傾斜圧延機で肉厚断面減少率で20～70%の成形加工を施し、更に前段傾斜圧延による加工発熱でAr3 点～1100℃まで昇温保持された中空粗管をその最終傾斜圧延機で肉厚断面減少率で20～70%の成形加工を施し、その後、形状矯正連続圧延をAr1 点～900℃の温度で20～70%の施した鋼管を、Ar3 点以上の温度から急冷する焼入処理を施した後、続いてAc1 点以下の温度に加熱して冷却する焼戻し処理を行うことを特徴とする破壊伝播特性の優れた高強度シームレス鋼管の製造法。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、破壊伝播特性の優れた高強度シームレス鋼管の製造法に関するものである。

【0002】

【従来の技術】近年、エネルギー資源としてガス井、油井開発は極北、高深度化する傾向にあり開発機材として使用されるシームレス鋼管に対しては、高強度、高靭性（破壊伝播特性）を兼ね備えた性質が要求されている。

【0003】従来より、このような諸特性を同時に満足するには、破壊時にセパレーション効果が発揮できる層状組織で且つ結晶粒度ASTM No. 6以上の微細組織が有効であることが本発明者等によって確かめられている。一方、熱間シームレス鋼管の圧延工程は、鋳造鋼片の穿孔圧延、延伸圧延、仕上圧延工程に分けられるが、成型体および表面品位の確保のため通常1100℃以上の高温域で加工が行なわれるため、セパレーション効果が発揮できる層状組織となりにくく、又圧延後の再結晶γ粒の成長が著しく、結晶粒度はASTM No. 6以下の粗粒組織となる。すなわち、近年の油井開発機材として要求される特性を満足するには層状組織とASTM No. 6以上の微細組織を安定して得る必要があるが、層状組織を有しASTM No. 6以上の微細組織を確保し破壊伝播特性の優れた高強度シームレス鋼管を得るには熱間シームレス圧延直後に焼入する直接焼入－焼戻し工程では不十分であった。

【0004】そのため、例えば特開昭52－77813号公報では熱間粗圧延した中空素管を強制的に一旦鋼のAr1 点以下に下げて再度オーステナイト化し引き続き行う仕上圧延後に焼入－焼戻し微細組織化するか、通常の仕上圧延後に再加熱焼入－焼戻しを行い徹底的に微細組織にする必要があった。

【0005】

【発明が解決しようとする課題】しかしながら、上記のような方法はいずれにおいても熱効率上の問題のほかに製造工程が煩雑となる欠点があった。一方、従来の熱間

シームレス圧延ままで近年の油井開発に要求される特性を満足できる必要条件である結晶粒度ASTMNo. 6以上が得られないため、直接焼入処理等の省工程で破壊伝播特性の優れた高強度シームレス鋼管が得られない問題があった。

【0006】本発明は、上記従来の問題点を解消すべく多くの実験を行い検討した結果なされたものであって、鋼成分、熱間圧延条件を制御することによって破壊伝播特性の優れた高強度シームレス鋼管の製造法を提供することを目的とする。

【0007】

【課題を解決するための手段】本発明は、前記目的を達成するために構成したものであり、その要旨とするところは、重量%として

C　：0．03～0．20%、　Si：0．01～0．5%、
Mn：0．15～2．5%、　P　：0．020%以下、
S　：0．005～0．1%、　Al：0．005～0．1%、
Ti：0．005～0．1%、　Nb：0．005～0．1%、
N　：0．01%以下

を含有し、更に必要によっては

Cr：0．1～1．5%、　Mo：0．05～0．5%、
Ni：0．1～2．0%、　V　：0．01～0．1%、
B　：0．0003～0．0033%、
希土類元素：0．001～0．05%、Ca：0．001～0．02%、
Co：0．05～0．5%、　Cu：0．1～0．5%

の1種又は2種以上を含有して残部が実質的にFeからなる鋼片を1100℃以上に加熱し熱間穿孔圧延した中空素管をAr3 点～1100℃まで冷却し、その直後の前段の傾斜圧延機で肉厚断面減少率で20～70%の成形加工を施し、更に前段傾斜圧延による加工時の発熱でAr3 点～1100℃まで昇温保持された中空粗管をその最終傾斜圧延機で肉厚断面減少率で20～70%の成形加工を施し、その後、形状矯正連続圧延をAr1 点～900℃の温度で20～70%の成形加工を施した鋼管を、Ar3 点以上の温度から急冷する焼入処理を施した後、続いてAc1 点以下の温度に加熱して冷却する焼戻し処理を行う耐SSC性の優れた高強度高靭性シームレス鋼管の製造法である。

【0008】以下本発明の製造法について詳細に説明する。先ず、本発明において上記のような鋼成分に限定した理由について説明する。C，Mnは、焼入効果を増して強度を高め降伏点30～60kgf/㎟ の高張力鋼を安

定して得るためおよび細粒化を図るため重要である。少な過ぎるとその効果がなく、多過ぎると焼割れの誘発および高硬度化し耐ＳＳＣ性の低下を来すためそれぞれ０．０３～０．２０%、０．１５～２．５%とした。

【０００９】Ｓｉは、脱酸剤が残存したもので強度を高める有効な成分である。少な過ぎるとその効果がなく、多過ぎると介在物を増加して耐ＳＳＣ性を低下させるため０．０１～０．５%とした。Ｐは、粒界偏析を起こして加工の際き裂を生じ易く有害な成分であり、又低温靭性の劣化をきたすためその含有量を０．０２０%以下とした。Ｓは、ＭｎＳ系介在物を形成して熱間連続圧延で延伸し層状組織を形成し、鋼の破壊伝播性能を改善する。少な過ぎるとその効果がなく、多過ぎると介在物を増加して鋼の性質を脆化するため０．００５～０．１%とした。

【００１０】Ａｌは、Ｓｉと同様脱酸剤が残存したもので、鋼中の不純物成分として含まれるＮと結合して結晶粒の成長を抑えて鋼の破壊伝播性能を改善する。少な過ぎるとその効果がなく、多過ぎると介在物を増加して鋼の性質を脆化するため０．００５～０．１%とした。

【００１１】Ｔｉ，Ｎｂは、いずれもシームレス圧延中の結晶粒径制御元素で、本発明の成分の中で最も重要な元素である。Ｔｉは、鋼中の不純物成分として含まれるＮと結合して、熱間圧延中の結晶粒制御および熱間圧延後の結晶粒の成長を抑え鋼の破壊伝播性能を改善すると共に、脱酸、脱窒の作用から後述のＢの焼入性を発揮させ強度を高める。少な過ぎるとその効果がなく、多過ぎるとＴｉＣを析出して鋼を脆化させるため０．００５～０．１%とした。一方、Ｎｂは、傾斜圧延中の結晶粒成長抑制および連続圧延後９００℃～Ar_1 点の温度まで降下した該素管を該温度より高い９００～１１００℃に加熱した場合のγ粒の異常粗大化を抑制する重要な元素である。少な過ぎるとその効果がなく、多過ぎてもその効果が飽和し、しかも非常に高価であるため０．００５～０．１%とした。

【００１２】Ｎは、後述のＢの焼入性を低下させる有害な成分として、その含有量を０．０１%以下とした。

【００１３】上記の成分組成の鋼で更に鋼の強度を高める場合Ｃｒ等の成分を必要に応じて選択的に添加する。Ｃｒ，Ｍｏ，Ｎｉ，Ｖは、鋼の焼入性を増して、強度を高めるために添加するものである。少な過ぎるとその効果がなく、多過ぎてもその効果が飽和し、しかも非常に高価であるため、それぞれ０．０１～１．５%、０．０５～０．５%、０．１～２．０%、０．０１～０．１%とした。Ｂは、焼入性を著しく向上せしめて強度を高める。少な過ぎるとその効果がなく、多過ぎても効果は変わらず、靭性や熱間加工性を劣化させるので０．０００３～０．００３%とした。

【００１４】更に本発明は、近年のシームレス鋼管の使用環境を鑑み上記の成分組成で構成される鋼の耐ＳＳＣ性を改善するために希土類元素等の成分を必要に応じて選択的に添加する。希土類元素、Ｃａは、介在物の形態を球状化させて無害化する有効な成分である。少な過ぎるとその効果がなく、多過ぎると介在物を増加して耐ＳＳＣ性を低下させるのでそれぞれ０．００１～０．０５%、０．００１～０．０２%とした。Ｃｏ，Ｃｕは、鋼中への水素侵入抑制効果があり耐ＳＳＣ性に有効に働く。少な過ぎるとその効果がなく、多過ぎるとその効果が飽和するためそれぞれ０．０５～０．５%、０．１～０．５%とした。

【００１５】次に熱間シームレス圧延条件を上記のように限定した理由について説明する。上記のような成分組成の鋼は転炉、電気炉等の溶解炉であるいは更に真空脱ガス処理を経て溶製され、連続鋳造法又は造塊分塊法で鋼片を製造する。鋼片は、直ちにあるいは一旦冷却された後高温に加熱し熱間穿孔圧延を行う。加熱温度は、熱間穿孔圧延を容易にするため十分高くしておかねばならない。本発明の成分範囲内であれば１１００℃以上の温度で熱間穿孔加工上なんら支障が生じないのでその温度は１１００℃以上とした。

【００１６】穿孔圧延が行なわれた中空素管は、前段の傾斜圧延機前でAr_3 点～１１００℃の温度に冷却し、直ちに粗加工する傾斜圧延を行う。傾斜圧延機（エロンゲーターミルなど）は、シームレス鋼管の圧延に使用される他の圧延機（マンドレルミル、プラグミルなど）や鋼板の圧延機と異なり、剪断ひずみの成分が非常に大きい。したがって、断面積減少率から予測されるひずみ量と比べて実質的なひずみ量は格段に大きい。このため、傾斜圧延機では小さな断面積減少率の加工であっても図１で示すように剪断ひずみの小さい圧延機と比べて細粒が得られ、又、加工発熱が大きいため直後の最終段の傾斜圧延に必要な温度の確保が可能となる。

【００１７】前段の傾斜圧延機で圧延された中空粗管はAr_3 点～１１００℃の温度に昇温保持され、最終段の傾斜圧延機で鋼管の最終形状に近い外径、肉厚まで粗加工する傾斜圧延を行う。最終段の傾斜圧延機の結晶粒径の微細化に対する効果は、図１に示した前段の傾斜圧延機と同様である。傾斜圧延機の圧延温度は、高いと再結晶粒の著しい成長が起こるが、低すぎると圧延負荷の増大により鋼の成形性が著しく低下し、目標とする外径、肉厚が得られにくく再結晶による結晶粒の微細化が図れないため、前段、最終段ともにAr_3 点～１１００℃に限定した。

【００１８】又、傾斜圧延機では前段、最終段共に再結晶は大部分動的に起こるので、結晶粒度は加工量によらない。しかし、再結晶する臨界ひずみは超えている必要がある。圧下率は、再結晶が圧延終了後にも静的に起こることを考慮して下限を２０%とした。一方、圧下率が余り大きすぎると、圧延が困難になりパイプの成形性や表面品位の低下が起こるため、上限を７０%とした。

【００１９】前段および最終段の傾斜圧延により微細化された該粗管は圧延終了後、Ａr1点～９００℃の温度で、更に形状矯正のため肉厚断面減少率で２０～７０％の連続圧延を行う。圧延温度は、連続圧延終了後の冷却でより微細組織を得るため、未再結晶の強い層状組織を得る必要があるためＡr1 点～９００℃とした。加工量は、あまり小さいと十分な層状組織が得られず、又、大きすぎると圧延負荷が大きくなり成形性が低下するため肉厚断面減少率で２０～７０％とした。

【００２０】以上の圧延により微細で且つ強い層状組織を得た該粗管は、Ａr3 点以上の温度から焼入処理を行う。焼入処理開始温度は、十分な焼入組織を確保し必要とする強度を確保するためＡr3 点以上とした。焼入時の冷却速度は特に限定しないが空冷より速い速度とする。

【００２１】焼入後、鋼の性質（脆性破壊伝播特性、強度、および耐ＳＳＣ性など）の安定化のため焼戻し処理

を行う。焼戻し温度は、強度および靭性の安定化を確保する必要からＡc1 点以下とした。その加熱方法については特に限定しない。

【００２２】以上の製造条件で得られるγは粗大粒を含むことなく脆性破壊伝播特性の優れた高強度高靭性シームレス鋼管の製造に有効である。

【００２３】

【実施例】次に本発明の実施例について説明する。表１は転炉で溶製し連続鋳造を経て製造された鋼片の化学成分であり（表１－１）、これを熱間シームレス圧延を行って直接焼入焼戻しした本発明法および従来法による鋼管の強度、脆性破壊伝播特性、γ粒度を表１－２に示した。本発明法によって製造された鋼管は、高強度を有しかつ従来法に比しγ粒度は微細であり高脆性破壊伝播特性が得られることがわかる。

【００２４】

【表１】

〔表1－1〕

製造方法	鋼	化学成分 (wt%)																
		C	Si	Mn	P	S	Al	Ti	Nb	Mo	Cr	Ni	V	Ca	B	Co	Cu	N
本発明法	1	.04	.23	1.60	.009	.003	.023	.012	.04	.00	.00	.00	.00	.0000	.000	.000	.00	.005
	2	.04	.24	1.54	.008	.003	.035	.012	.04	.00	.00	.00	.00	.0000	.000	.000	.00	.005
	3	.04	.22	1.54	.008	.003	.023	.012	.04	.00	.00	.00	.00	.0000	.000	.000	.00	.005
	4	.05	.44	1.54	.008	.003	.034	.012	.04	.00	.11	.00	.00	.0000	.000	.000	.00	.005
	5	.11	.44	1.43	.004	.042	.024	.023	.04	.00	.13	.00	.00	.0000	.000	.000	.00	.005
	6	.11	.25	1.38	.006	.041	.024	.025	.04	.00	.14	.00	.00	.0000	.000	.000	.00	.005
	7	.11	.11	1.35	.006	.042	.026	.025	.04	.00	.10	.00	.00	.0000	.000	.000	.00	.004
	8	.13	.15	2.03	.006	.053	.026	.025	.04	.32	.14	.00	.00	.0000	.009	.000	.00	.004
	9	.07	.23	1.20	.002	.001	.026	.018	.04	.00	.00	.00	.00	.0000	.000	.000	.00	.004
	10	.11	.27	1.20	.003	.001	.024	.018	.03	.00	.00	.00	.00	.0000	.000	.000	.00	.004
	11	.19	.25	1.20	.003	.001	.034	.015	.03	.00	.00	.00	.00	.0000	.000	.008	.22	.004
	12	.20	.25	1.20	.003	.001	.024	.015	.03	.00	.00	.00	.00	.0000	.000	.000	.00	.004
	13	.18	.32	0.43	.003	.001	.023	.015	.03	.11	.00	.15	.03	.0024	.001	.002	.00	.004
	14	.18	.31	0.58	.003	.002	.024	.014	.04	.11	.00	.15	.03	.0021	.001	.002	.00	.004
	15	.18	.30	0.05	.002	.002	.024	.011	.03	.12	.55	.50	.03	.0022	.001	.000	.00	.004
	16	.18	.35	0.50	.004	.002	.024	.050	.03	.11	.00	1.1	.08	.0021	.001	.000	.10	.004
従来法	17	.13	.21	1.30	.011	.003	.031	.000	.00	.20	.00	.00	.00	.0001	.000	.000	.00	.004
	18	.12	.22	1.85	.015	.001	.027	.015	.00	.35	.00	.00	.00	.0001	.000	.000	.00	.004
	19	.10	.11	1.53	.015	.001	.028	.015	.00	.33	.00	.00	.00	.0001	.000	.000	.00	.004
	20	.11	.20	1.44	.015	.001	.021	.015	.00	.24	.06	.00	.00	.0001	.000	.000	.00	.004
	21	.28	.10	0.33	.015	.001	.001	.000	.00	.40	.00	.00	.00	.0001	.000	.000	.00	.005
	22	.29	.22	0.65	.015	.001	.006	.000	.03	.05	.00	.00	.00	.0001	.000	.000	.00	.005
	23	.28	.21	0.54	.014	.001	.007	.000	.03	.00	.24	.00	.00	.0001	.000	.000	.00	.004
	24	.29	.20	0.57	.015	.002	.005	.000	.03	.00	.20	.00	.00	.0001	.000	.000	.00	.004

【0025】

＊ ＊【表2】

〔表1－2〕

製造方法	圧延条件 転炉－連続鋳造－＊シームレス圧延－DQ－T	鋼	YS (kgf/mm²)	DWTT－85%SATT (℃)	粒度 (ASTM No.)
本発明法	中空素管の冷却温度：1000℃ 前段傾斜圧延圧下量：40% 中空粗管の昇温温度：900℃ 最終傾斜圧延圧下量：40% 連続圧延温度：850℃ 連続圧延圧下量：20% 連続圧延後の降下温度：850℃ 仕上圧延温度：900℃	1	43	－40	10.8
		2	43	－50	10.7
		3	44	－40	10.9
		4	41	－40	11.6
		5	55	－60	10.6
		6	54	－60	11.5
		7	56	－60	11.3
		8	64	－60	10.5
	中空素管の冷却温度：950℃ 前段傾斜圧延圧下量：40% 中空粗管の昇温温度：1000℃ 最終傾斜圧延圧下量：60% 連続圧延温度：850℃ 連続圧延圧下量：25% 連続圧延後の降下温度：850℃ 仕上圧延温度：900℃	9	44	－50	11.2
		10	55	－40	12.5
		(11)	75	－50	11.2
		(12)	83 (118 Ksi)	－40	12.0
		(13)	73	－45	11.2
		(14)	76	－35	11.4
		(15)	71	－45	11.5
		(16)	74	－45	11.0
従来法	中空素管の冷却：なし 前段傾斜圧延圧下量：40% 中空粗管の昇温温度：1100℃ 最終傾斜圧延圧下量：40% 連続圧延温度：950℃ 連続圧延圧下量：20% 連続圧延後の降下温度：850℃ 仕上圧延温度：900℃	17	44	－15	5.4
		18	42	－10	5.2
		19	44	－5	5.5
		20	45	－15	5.3
		21	64	－0	5.4
		22	73	0	5.3
		23	74	15	5.5
		24	72	10	5.2

＊シームレス
圧　延：加熱（1200℃）－穿孔圧延－傾斜圧延－連続圧延－再加熱(950℃）－焼入温度:900℃－焼戻し温度:600℃

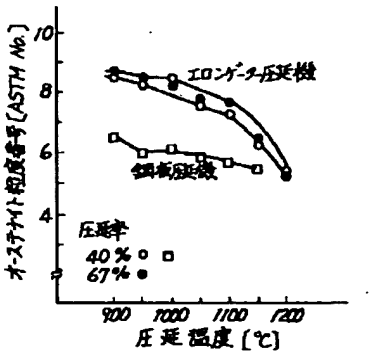
【0026】

【発明の効果】上記のような本発明法によって製造された鋼管は、高強度を有し更に細粒であるため脆性破壊伝播特性が優れ、極北の寒冷地において使用される。＊

＊【図面の簡単な説明】

【図1】通常の鋼板圧延法と傾斜圧延後のγ粒度と圧延温度の影響を示す図である。

【図1】


オーステナイト粒度番号〔ASTM No.〕
10
8
6
4
エロンゲータ圧延機
傾斜圧延機
圧延率
40％ ○ □
67％ ●
900
1000
1100
1200
圧延温度〔℃〕

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CLAIMS

[Claim(s)]
[Claim 1] It is C as weight %. : 0.03 - 0.20%, Si:0.01-0.5%, Mn: 0.15-2.5%, P : 0.020% or less, S : 0.005 - 0.1%, aluminum: 0.005-0.1%, Ti:0.005-0.1%, Nb:0.005-0.1%, N : it is the hollow element tube which carried out heating hot-piercing rolling of the slab with which 0.01% or less is contained and the remainder consists of Fe substantially at 1100 degrees C or more Ar3 It cools to point -1100 degree C. 20 - 70% of fabrication is performed with the thick reduction of area with the skew rolling machine of the preceding paragraph just behind that. Furthermore, it is Ar3 by processing generation of heat by preceding paragraph skew rolling. Perform hollow rough tubing by which temperature up maintenance was carried out to point -1100 degree C with the last skew rolling machine, and 20 - 70% of fabrication is performed with the thick reduction of area. Then, it is configuration correction continuation rolling Ar1 At point -900 degree C temperature, 20 - 70% of given steel pipe Ar3 After performing quenching treatment which quenches from the temperature beyond a point, it is Ac1 continuously. Manufacturing method of the high intensity seamless steel pipe which was excellent in the destructive propagation property characterized by performing tempering processing heated and cooled to the temperature below a point.
[Claim 2] As weight %, it is C. : 0.03 - 0.20%, Si:0.01-0.5%, Mn: 0.15-2.5%, P : 0.020% or less, S : 0.005 - 0.1%, aluminum:0.005-0.1%, Ti:0.005-0.1%, Nb:0.005-0.1%, N : 0.01% or less is contained. Furthermore, Cr:0.1-1.5%, Mo:0.05-0.5%, nickel:0.1-2.0%, V : 0.01 - 0.1%, B : It is the hollow element tube which heated the slab with which 0.0003 - 0.0033% of one sort or two sorts or more are contained, and the remainder consists of Fe substantially at 1100 degrees C or more, and carried out hot-piercing rolling Ar3 It cools to point -1100 degree C. 20 - 70% of fabrication is performed with the thick reduction of area with the skew rolling machine of the preceding paragraph just behind that. Furthermore, it is Ar3 by processing generation of heat by preceding paragraph skew rolling. Perform hollow rough tubing by which temperature up maintenance was carried out to point -1100 degree C with the last skew rolling machine, and 20 - 70% of fabrication is performed with the thick reduction of area. Then, it is configuration correction continuation rolling Ar1 At point -900 degree C temperature, 20 - 70% of given steel pipe Ar3 After performing quenching treatment which quenches from the temperature beyond a point, it is Ac1 continuously. Manufacturing method of the high intensity seamless steel pipe which was excellent in the destructive propagation property characterized by performing tempering processing heated and cooled to the temperature below a point.
[Claim 3] As weight %, it is C. : 0.03 - 0.20%, Si:0.01-0.5%, Mn: 0.15-2.5%, P : 0.020% or less, S : 0.005 - 0.1%, aluminum:0.005-0.1%, Ti:0.005-0.1%, Nb:0.005-0.1%, N : 0.01% or less is contained. Furthermore, rare earth elements : 0.001 - 0.05%, calcium:0.001-0.02%, Co: It is the hollow element tube which heated the slab with which one sort (0.05-0.5% and Cu:0.1-0.5%) or two sorts or more are contained, and the remainder consists of Fe substantially at 1100 degrees C or more, and carried out hot-piercing rolling Ar3 It cools to point -1100 degree C. 20 - 70% of fabrication is performed with the thick reduction of area with the skew rolling machine of the preceding paragraph just behind that. Furthermore, it is Ar3 by processing generation of heat by preceding paragraph skew rolling. Perform

hollow rough tubing by which temperature up maintenance was carried out to point -1100 degree C with the last skew rolling machine, and 20 - 70% of fabrication is performed with the thick reduction of area. Then, it is configuration correction continuation rolling Ar1 At point -900 degree C temperature, 20 - 70% of given steel pipe Ar3 After performing quenching treatment which quenches from the temperature beyond a point, it is Ac1 continuously. Manufacturing method of the high intensity seamless steel pipe which was excellent in the destructive propagation property characterized by performing tempering processing heated and cooled to the temperature below a point.

[Claim 4] As weight %, it is C. : 0.03 - 0.20%, Si:0.01-0.5%, Mn: 0.15-2.5%, P : 0.020% or less, S : 0.005 - 0.1%, aluminum:0.005-0.1%, Ti:0.005-0.1%, Nb:0.005-0.1%, N : 0.01% or less is contained. Furthermore, Cr:0.1-1.5%, Mo:0.05-0.5%, nickel:0.1-2.0%, V : 0.01 - 0.1%, B : 0.0003 - 0.0033% of one sort or two sorts or more, and rare earth elements : [0.001 - 0.05%,] calcium: It is the hollow element tube which heated the slab with which one sort (0.001-0.02%, Co:0.05-0.5%, and Cu:0.1-0.5%) or two sorts or more are contained, and the remainder consists of Fe substantially at 1100 degrees C or more, and carried out hot-piercing rolling Ar3 It cools to point -1100 degree C. 20 - 70% of fabrication is performed with the thick reduction of area with the skew rolling machine of the preceding paragraph just behind that. Furthermore, it is Ar3 by processing generation of heat by preceding paragraph skew rolling. Perform hollow rough tubing by which temperature up maintenance was carried out to point -1100 degree C with the last skew rolling machine, and 20 - 70% of fabrication is performed with the thick reduction of area. Then, it is configuration correction continuation rolling Ar1 At point -900 degree C temperature, 20 - 70% of given steel pipe Ar3 After performing quenching treatment which quenches from the temperature beyond a point, it is Ac1 continuously. Manufacturing method of the high intensity seamless steel pipe which was excellent in the destructive propagation property characterized by performing tempering processing heated and cooled to the temperature below a point.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the manufacturing method of the high intensity seamless steel pipe which was excellent in the destructive propagation property.
[0002]
[Description of the Prior Art] In recent years, from the gas well and the seamless steel pipe which the Yui development has in a north polar region and the inclination formed into high depth, and is used as development equipment and materials, the property which has high intensity and high toughness (destructive propagation property) is demanded as an energy resource.
[0003] It is the lamellar structure which can demonstrate the separation effectiveness conventionally at the time of destruction in order to satisfy such many properties simultaneously, and is a grain size number ASTM. It is confirmed by this invention person etc. that the detailed organization beyond No.6 is effective. It is hard to become the lamellar structure which can demonstrate the separation effectiveness on the other hand since processing is usually performed by the pyrosphere 1100 degrees C or more like the roll turner of the seamless steel pipe between heat for reservation of a molding object and surface grace, although divided like punching rolling of casting slab, drawing rolling, and a finish roll turner, and the recrystallization gamma grain growth after rolling is remarkable, and a grain size number is ASTM. It becomes a coarse-grain organization not more than No.6. That is, for satisfying the property demanded as Yui development equipment and materials in recent years, they are the lamellar structure and ASTM. It has the lamellar structure, although it is stabilized and it is necessary to obtain the detailed organization beyond No.6, and it is ASTM. The direct-quenching-tempering process of tempering obtaining the high intensity seamless steel pipe which secured the detailed organization beyond No.6 and was excellent in the destructive propagation property immediately after seamless rolling between heat was inadequate.
[0004] Therefore, it is once the hollow element tube which carried out hot rough rolling, for example by JP,52-77813,A compulsorily Ar1 of steel Quenching-tempering detailed systematization was carried out after finish rolling which lowers to below a point, austenitizes again and is performed succeedingly, or after the usual finish rolling, reheating quenching-annealing needed to be performed and it needed to carry out in the detailed organization thoroughly.
[0005]
[Problem(s) to be Solved by the Invention] However, the above approaches had the fault which becomes complicated [other than the problem on thermal efficiency / a production process] also in any. as [conventional seamless rolling / between heat /-on the other hand] -- it is -- an oil well in recent years -- since more than grain size number ASTMNo.6 that is the requirement with which can be satisfied of the property required of development was not obtained, there was a problem from which the high intensity seamless steel pipe which excelled [process saving /, such as direct-quenching processing,] in the destructive propagation property is not obtained.
[0006] This invention is made, as a result of experimenting in many and inquiring that the above-

mentioned conventional trouble should be canceled, and it aims at offering the manufacturing method of the high intensity seamless steel pipe which was excellent in the destructive propagation property by controlling a steel component and hot rolling conditions.

[0007]

[Means for Solving the Problem] The place which constitutes this invention in order to attain said object, and is made into the summary is C as weight %. : 0.03 - 0.20%, Si: 0.01-0.5%, Mn:0.15-2.5%, P : 0.020% or less, S : 0.005 - 0.1%, aluminum: 0.005-0.1%, Ti:0.005-0.1%, Nb: 0.005-0.1%, N : 0.01% or less is contained. Depending on the need, further Cr:0.1-1.5%, Mo: 0.05-0.5%, nickel:0.1-2.0%, V : 0.01 - 0.1%, B : 0.0003 - 0.0033%, rare earth elements : [0.001 - 0.05%, calcium:0.001-0.02%, Co:0.05-0.5%,] Cu: It is the hollow element tube which heated the slab with which one 0.1-0.5% sort or two sorts or more are contained, and the remainder consists of Fe substantially at 1100 degrees C or more, and carried out hot-piercing rolling Ar3 It cools to point -1100 degree C. 20 - 70% of fabricating operation is performed with the thick reduction of area with the skew rolling machine of the preceding paragraph just behind that. Furthermore, it is Ar3 by generation of heat at the time of processing by preceding paragraph skew rolling. Perform hollow rough tubing by which temperature-up maintenance was carried out to point -1100 degree C with the last skew rolling machine, and 20 - 70% of fabricating operation is performed with the thick reduction of area. Then, it is configuration correction continuous rolling Ar1 The steel pipe which performed 20 - 70% of fabricating operation at point -900 degree C temperature Ar3 After performing quenching treatment which quenches from the temperature beyond a point, it is Ac1 continuously. It is the manufacturing method of the high intensity high toughness seamless steel pipe which was excellent in the SSC-proof nature which performs tempering processing heated and cooled to the temperature below a point.

[0008] The manufacturing method of this invention is explained to a detail below. First, the reason limited to the above steel components in this invention is explained. The quenching effectiveness is increased, reinforcement is raised and C and Mn are 2 the 30 to 60 kgf/mm yield point. It is important in order to be stabilized and to obtain high tensile steel, and in order to attain grain refining. When too few, the effectiveness did not exist, and when many [too], induction of a quench crack, and in order to form a high degree of hardness and to cause lowering of SSC-proof nature, they could be 0.03 - 0.20%, and 0.15 - 2.5%, respectively.

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[0011] Each of Ti and Nb(s) is the diameter control elements of crystal grain under seamless rolling, and is the most important elements in the component of this invention. It demonstrates the hardenability of the below-mentioned B from deoxidation and an operation of denitrification, and raises reinforcement while Ti combines with N contained as an impurity component in steel, stops the grain growth after the crystal grain control under hot rolling, and hot rolling and improves the destructive communicability ability of steel. When too few, the effectiveness did not exist, and if many [too], in order to deposit TiC and to embrittle steel, it could be 0.005 - 0.1%. On the other hand, Nb is 900 degree-C-Ar1 after the grain growth control in skew rolling, and continuous rolling. It is the important element which controls abnormality big and rough-ization of gamma grain at the time of heating this element tube that

descended to the temperature of a point at 900-1100 degrees C higher than this temperature. When too few, the effectiveness did not exist, even if many [too], the effectiveness was saturated, and since it was moreover very expensive, it could be 0.005 - 0.1%.
[0012] N made the content 0.01% or less as a harmful component for which the hardenability of the below-mentioned B is reduced.
[0013] When the steel of the above-mentioned component presentation raises the reinforcement of steel further, components, such as Cr, are added selectively if needed. Cr, Mo, nickel, and V increase the hardenability of steel, and they are added in order to raise reinforcement. When too few, the effectiveness did not exist, even if many [too], the effectiveness was saturated, and since it was moreover very expensive, they could be 0.01 - 1.5%, 0.05 - 0.5%, 0.1 - 2.0%, and 0.01 - 0.1%, respectively. B makes hardenability improve remarkably and raises reinforcement. When too few, the effectiveness did not exist, and even if many [too], it did not change, but since effectiveness degraded toughness and hot-working nature, it was made into 0.0003 - 0.003%.
[0014] Furthermore, this invention adds components, such as rare earth elements, selectively if needed, in order to improve the SSC-proof nature of the steel which consists of above-mentioned component presentations in view of the operating environment of a seamless steel pipe in recent years. Rare earth elements and calcium are effective components which the gestalt of inclusion is made to spheroidize and are defanged. When too few, the effectiveness did not exist, and since inclusion is increased and SSC-proof nature was reduced when many [too], they could be 0.001 - 0.05%, and 0.001 - 0.02%, respectively. Co and Cu have the hydrogen trespass depressor effect to the inside of steel, and work effective in SSC-proof nature. When too few, the effectiveness did not exist, and since the effectiveness would be saturated if many [too], they could be 0.05 - 0.5%, and 0.1 - 0.5%, respectively.
[0015] Next, the reason which limited the seamless rolled bar affair between heat as mentioned above is explained. the steel of the above component presentations is fusion furnaces, such as a converter and an electric furnace, -- it is -- pass vacuum-degassing processing further -- it is ingoted and slab is manufactured by the continuous casting process or the ingot making cogging method. there is slab promptly -- it is -- once it is cooled, it heats to an elevated temperature and hot-piercing rolling is performed. Whenever [stoving temperature] must be made sufficiently high in order to make hot-piercing rolling easy. Since trouble did not arise at all on hot-piercing processing at the temperature of 1100 degrees C or more when it was component within the limits of this invention, the temperature was made into 1100 degrees C or more.
[0016] The hollow element tube to which punching rolling was performed is Ar3 before the skew rolling machine of the preceding paragraph. It cools to point -1100 degree C temperature, and skew rolling roughed promptly is performed. Unlike other rolling mills (a mandrel mill, plug mill, etc.) used for rolling of a seamless steel pipe, or the rolling mill of a steel plate, skew rolling machines (elongator mill etc.) have the dramatically large component of a shear strain. therefore, compared with the amount of strains predicted from cross-section percentage reduction, the substantial amount of strains is alike and large. For this reason, in a skew rolling machine, even if it is processing of small cross-section percentage reduction, as drawing 1 R> 1 shows, a fine grain is obtained compared with the small rolling mill of a shear strain, and since processing generation of heat is large, it becomes securable [temperature required for the skew rolling of the next last stage].
[0017] Hollow rough tubing rolled out with the skew rolling machine of the preceding paragraph is Ar3. Temperature-up maintenance is carried out at point -1100 degree C temperature, and skew rolling roughed to the outer diameter near the last configuration of a steel pipe and thickness with the skew rolling machine of the last stage is performed. The effectiveness over detailed-izing of the diameter of crystal grain of the skew rolling machine of the last stage is the same as that of the skew rolling machine of the preceding paragraph shown in drawing 1 . For the rolling temperature of a skew rolling machine, since remarkable growth of a recrystallization grain will take place if high, but detailed-ization of the crystal grain by recrystallization cannot be attained that the moldability of steel falls remarkably according to buildup of a rolling load, and a target outer diameter and thickness are hard to be obtained if too low, the preceding paragraph and the last stage are Ar3. It limited to point -1100 degree C.

[0018] Moreover, in a skew rolling machine, since a great portion of recrystallization takes place dynamically, a grain size number does not depend the preceding paragraph and the last stage on the amount of processings. However, it is necessary to be over the critical strain to recrystallize. Rolling reduction made the minimum 20% in consideration of happening statically [recrystallization] also after rolling termination. On the other hand, if rolling reduction was too large not much, since rolling would become difficult and the moldability of a pipe and deterioration of surface grace would take place, the upper limit was made into 70%.

[0019] This rough tubing made detailed by the skew rolling of the preceding paragraph and the last stage performs 20 - 70% of continuous rolling with the thick reduction of area further at the temperature of one - 900 degree C of Ar(s) after rolling termination for configuration correction. Since it is necessary to obtain the strong non-recrystallized lamellar structure in order to obtain a detailed organization more by cooling after continuous rolling termination, rolling temperature is Ar1. It could be point -900 degree C. Since a rolling load would become large and a moldability would fall if sufficient lamellar structure obtains and is too large when not much small, the amount of processings was made into 20 - 70% with the thick reduction of area.

[0020] This rough tubing that obtained the strong detailed and lamellar structure with the above rolling is Ar3. Quenching treatment is performed from the temperature beyond a point. Quenching treatment initiation temperature is Ar3 in order to secure the reinforcement which secures and needs sufficient hardened structure. It carried out to beyond the point. Although especially the cooling rate at the time of quenching is not limited, let it be a rate quicker than air cooling.

[0021] Tempering processing is performed after quenching for stabilization of the properties (a brittle fracture propagation property, reinforcement, SSC-proof nature, etc.) of steel. Tempering temperature is the need of securing stabilization of reinforcement and toughness to Ac1. It carried out to below the point. It does not limit especially about the heating approach.

[0022] gamma obtained on the above manufacture conditions is effective in manufacture of the high intensity high toughness seamless steel pipe which was excellent in the brittle fracture propagation property, without including a big and rough grain.

[0023]

[Example] Next, the example of this invention is explained. A table 1 is the chemical entity of the slab which ingoted with the converter and was manufactured through continuous casting (table 1-1), and showed the reinforcement of the steel pipe by this invention method and conventional method which performed seamless rolling between heat and carried out direct-quenching annealing of this, a brittle fracture propagation property, and gamma grain size in a table 1-2. The steel pipe manufactured by this invention method has high intensity, and compares it with a conventional method, and gamma grain size is detailed and it turns out that a high brittle fracture propagation property is acquired.

[0024]

[A table 1]

〔表1－1〕

製造方法	鋼	化学成分 (wt%)																
		C	Si	Mn	P	S	Aℓ	Ti	Nb	Mo	Cr	Ni	V	Ca	B	Co	Cu	N
本発明法	1	.04	.23	1.60	.009	.003	.023	.012	.04	.00	.00	.00	.00	.0000	.000	.000	.00	.005
	2	.04	.24	1.54	.008	.003	.035	.012	.04	.00	.00	.00	.00	.0000	.000	.000	.00	.005
	3	.04	.22	1.54	.008	.003	.023	.012	.04	.00	.00	.00	.00	.0000	.000	.000	.00	.005
	4	.05	.44	1.54	.008	.003	.034	.012	.04	.00	.11	.00	.00	.0000	.000	.000	.00	.005
	5	.11	.44	1.43	.004	.042	.024	.023	.04	.00	.13	.00	.00	.0000	.000	.000	.00	.005
	6	.11	.25	1.38	.006	.041	.024	.025	.04	.00	.14	.00	.00	.0000	.000	.000	.00	.005
	7	.11	.11	1.35	.006	.042	.026	.025	.04	.00	.10	.00	.00	.0000	.000	.000	.00	.004
	8	.13	.15	2.03	.006	.053	.026	.025	.04	.32	.14	.00	.00	.0000	.009	.000	.00	.004
	9	.07	.23	1.20	.002	.001	.026	.018	.04	.00	.00	.00	.00	.0000	.000	.000	.00	.004
	10	.11	.27	1.20	.003	.001	.024	.018	.03	.00	.00	.00	.00	.0000	.000	.000	.00	.004
	11	.19	.25	1.20	.003	.001	.034	.015	.03	.00	.00	.00	.00	.0000	.000	.008	.22	.004
	12	.20	.25	1.20	.003	.001	.024	.015	.03	.00	.00	.00	.00	.0000	.000	.000	.00	.004
	13	.18	.32	0.43	.003	.001	.023	.015	.03	.11	.00	.15	.03	.0024	.001	.002	.00	.004
	14	.18	.31	0.58	.003	.002	.024	.014	.04	.11	.00	.15	.03	.0021	.001	.002	.00	.004
	15	.18	.30	0.05	.002	.002	.024	.011	.03	.12	.55	.50	.03	.0022	.001	.000	.00	.004
	16	.18	.35	0.50	.004	.002	.024	.050	.03	.11	.00	1.1	.08	.0021	.001	.000	.10	.004
従来法	17	.13	.21	1.30	.011	.003	.031	.000	.00	.20	.00	.00	.00	.0001	.000	.000	.00	.004
	18	.12	.22	1.65	.015	.001	.027	.015	.00	.35	.00	.00	.00	.0001	.000	.000	.00	.004
	19	.10	.11	1.53	.015	.001	.028	.015	.00	.33	.00	.00	.00	.0001	.000	.000	.00	.004
	20	.11	.20	1.44	.015	.001	.021	.015	.00	.24	.06	.00	.00	.0001	.000	.000	.00	.004
	21	.28	.10	0.33	.015	.001	.001	.000	.00	.40	.00	.00	.00	.0001	.000	.000	.00	.005
	22	.29	.22	0.65	.015	.001	.006	.000	.03	.05	.00	.00	.00	.0001	.000	.000	.00	.005
	23	.28	.21	0.54	.014	.001	.007	.000	.03	.00	.24	.00	.00	.0001	.000	.000	.00	.004
	24	.29	.20	0.57	.015	.002	.005	.000	.03	.00	.20	.00	.00	.0001	.000	.000	.00	.004

[0025]
[A table 2]

〔表1－2〕

製造方法	圧延条件 転炉－連続鋳造－＊シームレス圧延－DQ－T	鋼	YS (kgf/mm²)	DWTT－85%SATT (℃)	粒度 (ASTM No.)
本発明法	中空素管の冷却温度：1000℃	1	43	－40	10.8
	前段傾斜圧延圧下量：40%	2	43	－50	10.7
	中空粗管の昇温温度：900℃	3	44	－40	10.9
	最終傾斜圧延圧下量：40%	4	41	－40	11.6
	連続圧延温度：850℃	5	55	－60	10.6
	連続圧延圧下量：20%	6	54	－60	11.5
	連続圧延後の降下温度：850℃	7	56	－60	11.3
	仕上圧延温度：900℃	8	64	－60	10.5
	中空素管の冷却温度：950℃	9	44	－50	11.2
	前段傾斜圧延圧下量：40%	10	55	－40	12.5
	中空粗管の昇温温度：1000℃	11	75	－50	11.2
	最終傾斜圧延圧下量：60%	12	83	－40	12.0
	連続圧延温度：850℃	13	73	－45	11.2
	連続圧延圧下量：25%	14	76	－35	11.4
	連続圧延後の降下温度：850℃	15	71	－45	11.5
	仕上圧延温度：900℃	16	74	－45	11.0
従来法	中空素管の冷却：なし	17	44	－15	5.4
	前段傾斜圧延圧下量：40%	18	42	－10	5.2
	中空粗管の昇温温度：1100℃	19	44	－ 5	5.5
	最終傾斜圧延圧下量：40%	20	45	－15	5.3
	連続圧延温度：950℃	21	64	－ 0	5.4
	連続圧延圧下量：20%	22	73	0	5.3
	連続圧延後の降下温度：850℃	23	74	15	5.5
	仕上圧延温度：900℃	24	72	10	5.2

＊シームレス

圧 延：加熱（1200℃）－穿孔圧延－傾斜圧延－連続圧延－再加熱(950℃）－焼入温度:900℃－焼戻し温度:600℃

[0026]

[Effect of the Invention] The steel pipe manufactured by the above this invention methods has high intensity, since it is a fine grain further, a brittle fracture propagation property is excellent, and it is used in the cold district of a north polar region.

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the manufacturing method of the high intensity seamless steel pipe which was excellent in the destructive propagation property.
[0002]
[Description of the Prior Art] In recent years, from the gas well and the seamless steel pipe which the Yui development has in a north polar region and the inclination formed into high depth, and is used as development equipment and materials, the property which has high intensity and high toughness (destructive propagation property) is demanded as an energy resource.
[0003] It is the lamellar structure which can demonstrate the separation effectiveness conventionally at the time of destruction in order to satisfy such many properties simultaneously, and is a grain size number ASTM. It is confirmed by this invention person etc. that the detailed organization beyond No.6 is effective. It is hard to become the lamellar structure which can demonstrate the separation effectiveness on the other hand since processing is usually performed by the pyrosphere 1100 degrees C or more like the roll turner of the seamless steel pipe between heat for reservation of a molding object and surface grace, although divided like punching rolling of casting slab, drawing rolling, and a finish roll turner, and the recrystallization gamma grain growth after rolling is remarkable, and a grain size number is ASTM. It becomes a coarse-grain organization not more than No.6. That is, for satisfying the property demanded as Yui development equipment and materials in recent years, they are the lamellar structure and ASTM. It has the lamellar structure, although it is stabilized and it is necessary to obtain the detailed organization beyond No.6, and it is ASTM. The direct-quenching-tempering process of tempering obtaining the high intensity seamless steel pipe which secured the detailed organization beyond No.6 and was excellent in the destructive propagation property immediately after seamless rolling between heat was inadequate.
[0004] Therefore, it is once the hollow element tube which carried out hot rough rolling, for example by JP,52-77813,A compulsorily Ar1 of steel Quenching-tempering detailed systematization was carried out after finish rolling which lowers to below a point, austenitizes again and is performed succeedingly, or after the usual finish rolling, reheating quenching-annealing needed to be performed and it needed to carry out in the detailed organization thoroughly.
[0005]
[Problem(s) to be Solved by the Invention] However, the above approaches had the fault which becomes complicated [other than the problem on thermal efficiency / a production process] also in any. as [conventional seamless rolling / between heat /-on the other hand] -- it is -- an oil well in recent years -- since more than grain size number ASTMNo.6 that is the requirement with which can be satisfied of the property required of development was not obtained, there was a problem from which the high intensity seamless steel pipe which excelled [process saving /, such as direct-quenching processing,] in the destructive propagation property is not obtained.
[0006] This invention is made, as a result of experimenting in many and inquiring that the above-

mentioned conventional trouble should be canceled, and it aims at offering the manufacturing method of the high intensity seamless steel pipe which was excellent in the destructive propagation property by controlling a steel component and hot rolling conditions.

[0007]

[Means for Solving the Problem] The place which constitutes this invention in order to attain said object, and is made into the summary is C as weight %. : 0.03 - 0.20%, Si: 0.01-0.5%, Mn:0.15-2.5%, P : 0.020% or less, S : 0.005 - 0.1%, aluminum: 0.005-0.1%, Ti:0.005-0.1%, Nb: 0.005-0.1%, N : 0.01% or less is contained. Depending on the need, further Cr:0.1-1.5%, Mo: 0.05-0.5%, nickel:0.1-2.0%, V : 0.01 - 0.1%, B : 0.0003 - 0.0033%, rare earth elements : [0.001 - 0.05%, calcium:0.001-0.02%, Co:0.05-0.5%,] Cu: It is the hollow element tube which heated the slab with which one 0.1-0.5% sort or two sorts or more are contained, and the remainder consists of Fe substantially at 1100 degrees C or more, and carried out hot-piercing rolling Ar3 It cools to point -1100 degree C. 20 - 70% of fabricating operation is performed with the thick reduction of area with the skew rolling machine of the preceding paragraph just behind that. Furthermore, it is Ar3 by generation of heat at the time of processing by preceding paragraph skew rolling. Perform hollow rough tubing by which temperature-up maintenance was carried out to point -1100 degree C with the last skew rolling machine, and 20 - 70% of fabricating operation is performed with the thick reduction of area. Then, it is configuration correction continuous rolling Ar1 The steel pipe which performed 20 - 70% of fabricating operation at point -900 degree C temperature Ar3 After performing quenching treatment which quenches from the temperature beyond a point, it is Ac1 continuously. It is the manufacturing method of the high intensity high toughness seamless steel pipe which was excellent in the SSC-proof nature which performs tempering processing heated and cooled to the temperature below a point.

[0008] The manufacturing method of this invention is explained to a detail below. First, the reason limited to the above steel components in this invention is explained. The quenching effectiveness is increased, reinforcement is raised and C and Mn are 2 the 30 to 60 kgf/mm yield point. It is important in order to be stabilized and to obtain high tensile steel, and in order to attain grain refining. When too few, the effectiveness did not exist, and when many [too], induction of a quench crack, and in order to form a high degree of hardness and to cause lowering of SSC-proof nature, they could be 0.03 - 0.20%, and 0.15 - 2.5%, respectively.

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descended to the temperature of a point at 900-1100 degrees C higher than this temperature. When too few, the effectiveness did not exist, even if many [too], the effectiveness was saturated, and since it was moreover very expensive, it could be 0.005 - 0.1%.

[0012] N made the content 0.01% or less as a harmful component for which the hardenability of the below-mentioned B is reduced.

[0013] When the steel of the above-mentioned component presentation raises the reinforcement of steel further, components, such as Cr, are added selectively if needed. Cr, Mo, nickel, and V increase the hardenability of steel, and they are added in order to raise reinforcement. When too few, the effectiveness did not exist, even if many [too], the effectiveness was saturated, and since it was moreover very expensive, they could be 0.01 - 1.5%, 0.05 - 0.5%, 0.1 - 2.0%, and 0.01 - 0.1%, respectively. B makes hardenability improve remarkably and raises reinforcement. When too few, the effectiveness did not exist, and even if many [too], it did not change, but since effectiveness degraded toughness and hot-working nature, it was made into 0.0003 - 0.003%.

[0014] Furthermore, this invention adds components, such as rare earth elements, selectively if needed, in order to improve the SSC-proof nature of the steel which consists of above-mentioned component presentations in view of the operating environment of a seamless steel pipe in recent years. Rare earth elements and calcium are effective components which the gestalt of inclusion is made to spheroidize and are defanged. When too few, the effectiveness did not exist, and since inclusion is increased and SSC-proof nature was reduced when many [too], they could be 0.001 - 0.05%, and 0.001 - 0.02%, respectively. Co and Cu have the hydrogen trespass depressor effect to the inside of steel, and work effective in SSC-proof nature. When too few, the effectiveness did not exist, and since the effectiveness would be saturated if many [too], they could be 0.05 - 0.5%, and 0.1 - 0.5%, respectively.

[0015] Next, the reason which limited the seamless rolled bar affair between heat as mentioned above is explained. the steel of the above component presentations is fusion furnaces, such as a converter and an electric furnace, -- it is -- pass vacuum-degassing processing further -- it is ingoted and slab is manufactured by the continuous casting process or the ingot making cogging method. there is slab promptly -- it is -- once it is cooled, it heats to an elevated temperature and hot-piercing rolling is performed. Whenever [stoving temperature] must be made sufficiently high in order to make hot-piercing rolling easy. Since trouble did not arise at all on hot-piercing processing at the temperature of 1100 degrees C or more when it was component within the limits of this invention, the temperature was made into 1100 degrees C or more.

[0016] The hollow element tube to which punching rolling was performed is Ar3 before the skew rolling machine of the preceding paragraph. It cools to point -1100 degree C temperature, and skew rolling roughed promptly is performed. Unlike other rolling mills (a mandrel mill, plug mill, etc.) used for rolling of a seamless steel pipe, or the rolling mill of a steel plate, skew rolling machines (elongator mill etc.) have the dramatically large component of a shear strain. therefore, compared with the amount of strains predicted from cross-section percentage reduction, the substantial amount of strains is alike and large. For this reason, in a skew rolling machine, even if it is processing of small cross-section percentage reduction, as drawing 1 R> 1 shows, a fine grain is obtained compared with the small rolling mill of a shear strain, and since processing generation of heat is large, it becomes securable [temperature required for the skew rolling of the next last stage].

[0017] Hollow rough tubing rolled out with the skew rolling machine of the preceding paragraph is Ar3. Temperature-up maintenance is carried out at point -1100 degree C temperature, and skew rolling roughed to the outer diameter near the last configuration of a steel pipe and thickness with the skew rolling machine of the last stage is performed. The effectiveness over detailed-izing of the diameter of crystal grain of the skew rolling machine of the last stage is the same as that of the skew rolling machine of the preceding paragraph shown in drawing 1 . For the rolling temperature of a skew rolling machine, since remarkable growth of a recrystallization grain will take place if high, but detailed-ization of the crystal grain by recrystallization cannot be attained that the moldability of steel falls remarkably according to buildup of a rolling load, and a target outer diameter and thickness are hard to be obtained if too low, the preceding paragraph and the last stage are Ar3. It limited to point -1100 degree C.

[0018] Moreover, in a skew rolling machine, since a great portion of recrystallization takes place dynamically, a grain size number does not depend the preceding paragraph and the last stage on the amount of processings. However, it is necessary to be over the critical strain to recrystallize. Rolling reduction made the minimum 20% in consideration of happening statically [recrystallization] also after rolling termination. On the other hand, if rolling reduction was too large not much, since rolling would become difficult and the moldability of a pipe and deterioration of surface grace would take place, the upper limit was made into 70%.

[0019] This rough tubing made detailed by the skew rolling of the preceding paragraph and the last stage performs 20 - 70% of continuous rolling with the thick reduction of area further at the temperature of one - 900 degree C of Ar(s) after rolling termination for configuration correction. Since it is necessary to obtain the strong non-recrystallized lamellar structure in order to obtain a detailed organization more by cooling after continuous rolling termination, rolling temperature is Ar1. It could be point -900 degree C. Since a rolling load would become large and a moldability would fall if sufficient lamellar structure obtains and is too large when not much small, the amount of processings was made into 20 - 70% with the thick reduction of area.

[0020] This rough tubing that obtained the strong detailed and lamellar structure with the above rolling is Ar3. Quenching treatment is performed from the temperature beyond a point. Quenching treatment initiation temperature is Ar3 in order to secure the reinforcement which secures and needs sufficient hardened structure. It carried out to beyond the point. Although especially the cooling rate at the time of quenching is not limited, let it be a rate quicker than air cooling.

[0021] Tempering processing is performed after quenching for stabilization of the properties (a brittle fracture propagation property, reinforcement, SSC-proof nature, etc.) of steel. Tempering temperature is the need of securing stabilization of reinforcement and toughness to Ac1. It carried out to below the point. It does not limit especially about the heating approach.

[0022] gamma obtained on the above manufacture conditions is effective in manufacture of the high intensity high toughness seamless steel pipe which was excellent in the brittle fracture propagation property, without including a big and rough grain.

[0023]

[Example] Next, the example of this invention is explained. A table 1 is the chemical entity of the slab which ingoted with the converter and was manufactured through continuous casting (table 1-1), and showed the reinforcement of the steel pipe by this invention method and conventional method which performed seamless rolling between heat and carried out direct-quenching annealing of this, a brittle fracture propagation property, and gamma grain size in a table 1-2. The steel pipe manufactured by this invention method has high intensity, and compares it with a conventional method, and gamma grain size is detailed and it turns out that a high brittle fracture propagation property is acquired.

[0024]

[A table 1]

(表1－1)

製造方法	鋼	化学成分 (wt%)																		
		C	Si	Mn	P	S	Al	Ti	Nb	Mo	Cr	Ni	V	Ca	B	Co	Cu	N
本発明法	1	.04	.23	1.60	.009	.003	.023	.012	.04	.00	.00	.00	.00	.0000	.000	.000	.00	.005
	2	.04	.24	1.54	.008	.003	.035	.012	.04	.00	.00	.00	.00	.0000	.000	.000	.00	.005
	3	.04	.22	1.54	.008	.003	.023	.012	.04	.00	.00	.00	.00	.0000	.000	.000	.00	.005
	4	.05	.44	1.54	.008	.003	.034	.012	.04	.00	.11	.00	.00	.0000	.000	.000	.00	.005
	5	.11	.44	1.43	.004	.042	.024	.023	.04	.00	.13	.00	.00	.0000	.000	.000	.00	.005
	6	.11	.25	1.38	.006	.041	.024	.025	.04	.00	.14	.00	.00	.0000	.000	.000	.00	.005
	7	.11	.11	1.35	.006	.042	.026	.025	.04	.00	.10	.00	.00	.0000	.000	.000	.00	.004
	8	.13	.15	2.03	.006	.053	.026	.025	.04	.32	.14	.00	.00	.0000	.009	.000	.00	.004
	9	.07	.23	1.20	.002	.001	.026	.018	.04	.00	.00	.00	.00	.0000	.000	.000	.00	.004
	10	.11	.27	1.20	.003	.001	.024	.018	.03	.00	.00	.00	.00	.0000	.000	.000	.00	.004
	11	.19	.25	1.20	.003	.001	.034	.015	.03	.00	.00	.00	.00	.0000	.000	.008	.22	.004
	12	.20	.25	1.20	.003	.001	.024	.015	.03	.00	.00	.00	.00	.0000	.000	.000	.00	.004
	13	.18	.32	0.43	.003	.001	.023	.015	.03	.11	.00	.15	.03	.0024	.001	.002	.00	.004
	14	.18	.31	0.58	.003	.002	.024	.014	.04	.11	.00	.15	.03	.0021	.001	.002	.00	.004
	15	.18	.30	0.05	.002	.002	.024	.011	.03	.12	.55	.50	.03	.0022	.001	.000	.00	.004
	16	.18	.35	0.50	.004	.002	.024	.050	.03	.11	.00	1.1	.08	.0021	.001	.000	.10	.004
従来法	17	.13	.21	1.30	.011	.003	.031	.000	.00	.20	.00	.00	.00	.0001	.000	.000	.00	.004
	18	.12	.22	1.65	.015	.001	.027	.015	.00	.35	.00	.00	.00	.0001	.000	.000	.00	.004
	19	.10	.11	1.53	.015	.001	.028	.015	.00	.33	.00	.00	.00	.0001	.000	.000	.00	.004
	20	.11	.20	1.44	.015	.001	.021	.015	.00	.24	.06	.00	.00	.0001	.000	.000	.00	.004
	21	.28	.10	0.33	.015	.001	.001	.000	.00	.40	.00	.00	.00	.0001	.000	.000	.00	.005
	22	.29	.22	0.65	.015	.001	.006	.000	.03	.05	.00	.00	.00	.0001	.000	.000	.00	.005
	23	.28	.21	0.54	.014	.001	.007	.000	.03	.00	.24	.00	.00	.0001	.000	.000	.00	.004
	24	.29	.20	0.57	.015	.002	.005	.000	.03	.00	.20	.00	.00	.0001	.000	.000	.00	.004

[0025]
[A table 2]

〔表１－２〕

製造方法	圧延条件 転炉－連続鋳造－ *シームレス 圧延－ＤＱ－Ｔ	鋼	ＹＳ (kgf/mm²)	ＤＷＴＴ－85％ＳＡＴＴ (℃)	粒度 (ASTM No.)
本発明法	中空素管の冷却温度：1000℃ 前段傾斜圧延圧下量：40% 中空粗管の昇温温度：900℃ 最終傾斜圧延圧下量：40% 連続圧延温度：850℃ 連続圧延圧下量：20% 連続圧延後の降下温度：850℃ 仕上圧延温度：900℃	1	43	－40	10.8
		2	43	－50	10.7
		3	44	－40	10.9
		4	41	－40	11.6
		5	55	－60	10.6
		6	54	－60	11.5
		7	56	－60	11.3
		8	64	－60	10.5
	中空素管の冷却温度：950℃ 前段傾斜圧延圧下量：40% 中空粗管の昇温温度：1000℃ 最終傾斜圧延圧下量：60% 連続圧延温度：850℃ 連続圧延圧下量：25% 連続圧延後の降下温度：850℃ 仕上圧延温度：900℃	9	44	－50	11.2
		10	55	－40	12.5
		11	75	－50	11.2
		12	83	－40	12.0
		13	73	－45	11.2
		14	76	－35	11.4
		15	71	－45	11.5
		16	74	－45	11.0
従来法	中空素管の冷却：なし 前段傾斜圧延圧下量：40% 中空粗管の昇温温度：1100℃ 最終傾斜圧延圧下量：40% 連続圧延温度：950℃ 連続圧延圧下量：20% 連続圧延後の降下温度：850℃ 仕上圧延温度：900℃	17	44	－15	5.4
		18	42	－10	5.2
		19	44	－ 5	5.5
		20	45	－15	5.3
		21	64	－ 0	5.4
		22	73	0	5.3
		23	74	15	5.5
		24	72	10	5.2

＊シームレス

圧　延：加熱（1200℃）－穿孔圧延－傾斜圧延－連続圧延－再加熱(950℃）－焼入温度:900℃－焼戻し温度:600℃

[0026]

[Effect of the Invention] The steel pipe manufactured by the above this invention methods has high intensity, since it is a fine grain further, a brittle fracture propagation property is excellent, and it is used in the cold district of a north polar region.